

Fault Tolerant Aerospace/ Commercial Heat Exchanger

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In most all fluid heat transfer systems, a device, or heat exchanger, must be included which rejects heat from one portion of the system to another. The heat exchanger provides two functions. It is both a connection and barrier to the heat collection and heat rejection portions of the thermal control system (TCS). More often than not, multiple fluids, as shown in figure 63, are utilized in the system for reasons of efficiency which may cause safety and/or reliability problems.

Essentially two failure modes exist, a breach to the environment (i.e. a fluid may be toxic if released into the environment) or

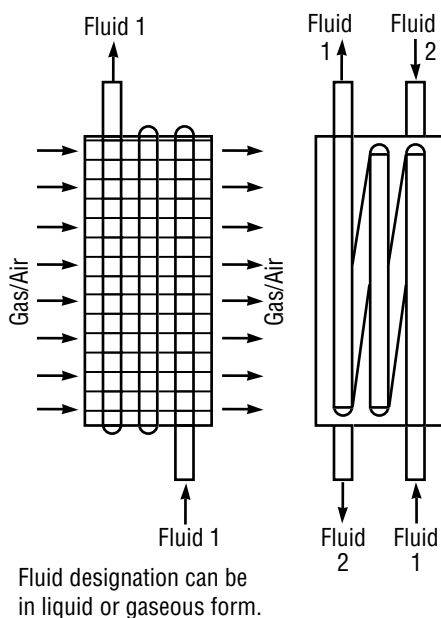


FIGURE 63.—Typical heat exchanger design.

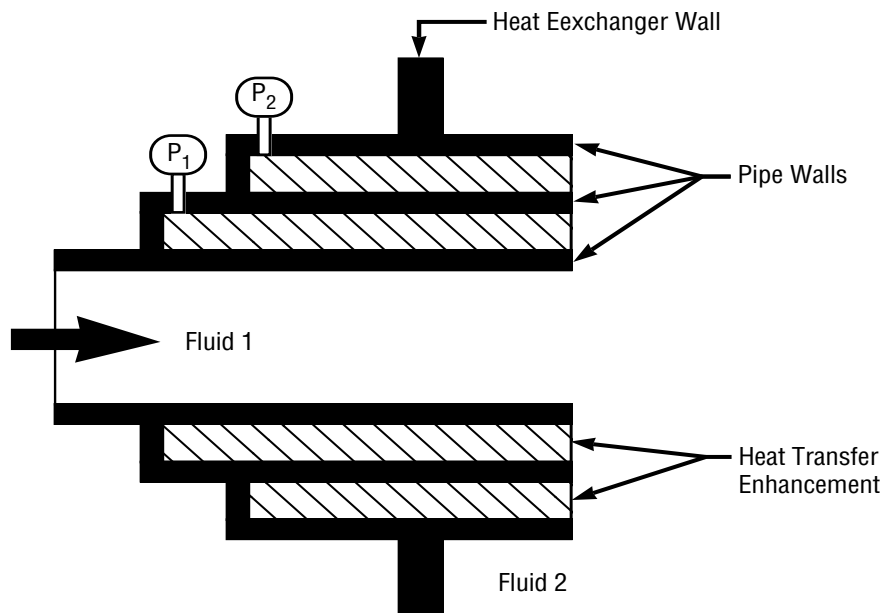


FIGURE 64.—Two fault-tolerant heat exchanger tube design.

a system breach across the two heat transfer loops (i.e. two fluids are utilized which are hazardous when mixed). If the first failure mode is of concern, then often-added reliability must be incorporated to ensure that the second failure mode discussed does not also cause the first—release to the environment. This might be the case if materials were not compatible with both fluids or if large mismatches in design pressure were present. In order to accomplish isolation, strict attention must be given to these types of factors often resulting in high system costs. A rather simple solution to the aforescribed problem is a fault-tolerant heat exchanger.

The proposed device will allow TCS fluids to be utilized in different portions of the system which are neither chemically compatible nor have similar operating pressures. By increasing the number of barriers across the single device, required isolation is relieved at other sections of the loop, thereby increasing the reliability with minimal impact to cost, weight and efficiency.

By incorporating additional barriers in the heat exchanger only, additional failures can be tolerated at the interface allowing less attention to the system as a whole. An example design, shown in figure 64, allows for two failures with no operational impact to the system. At the fluid interface, multiple structural barriers are added, which in this case are pipes. The void between each pipe can then be filled with a variety of heat transfer enhancement materials to maintain the thermal efficiency of the device.

An additional benefit exists if the voids are also filled with a gas charged at a different pressure than either system operating pressure. By gas charging the voids instrumentation can also be applied which will allow failure monitoring to occur at the interface. This would be advantageous in systems which require a planned shutdown and heat exchanger failure is a concern. For these systems, monitoring for failures allows the system to continue operation (after one or more failures have occurred) until the system can be shut down by the required procedure.



The proposed design approach can be applied to essentially any heat exchanger design (shell and tube, thin wall, etc.) offering the possibility of increased system performance in a variety of areas where fluid release/mixing/design pressure is a concern. The multiple barriers allow less detailed attention to the total system design and may also decrease costs by improving reliability.

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Biographical Sketch: Jon Holladay is a thermal engineer in the Environmental Control and Life Support Branch. He earned his bachelor and master of science degrees at the University of Alabama. 